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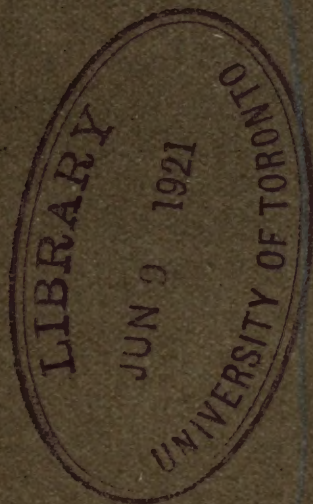
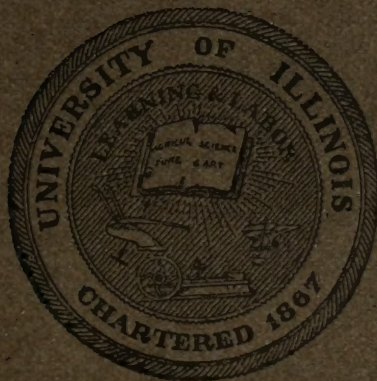
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THE FUNCTIONS OF THE ENGINEERING
EXPERIMENT STATION OF THE
UNIVERSITY OF ILLINOIS

BY

CHARLES RUSS RICHARDS



CIRCULAR No. 9

ENGINEERING EXPERIMENT STATION

PUBLISHED BY THE UNIVERSITY OF ILLINOIS, URBANA

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THE Engineering Experiment Station was established by act of the Board of Trustees of the University of Illinois on December 8, 1903. It is the purpose of the Station to conduct investigations and make studies of importance to the engineering, manufacturing, railway, mining, and other industrial interests of the State.

The management of the Engineering Experiment Station is vested in an Executive Staff composed of the Director and his Assistant, the Heads of the several Departments in the College of Engineering, and the Professor of Industrial Chemistry. This Staff is responsible for the establishment of general policies governing the work of the Station, including the approval of material for publication. All members of the teaching staff of the College are encouraged to engage in scientific research, either directly or in coöperation with the Research Corps composed of full-time research assistants, research graduate assistants, and special investigators.

To render the results of its scientific investigations available to the public, the Engineering Experiment Station publishes and distributes a series of bulletins. Occasionally it publishes circulars of timely interest, presenting information of importance, compiled from various sources which may not readily be accessible to the clientele of the Station.

The volume and number at the top of the front cover page are merely arbitrary numbers and refer to the general publications of the University. *Either above the title or below the seal* is given the number of the Engineering Experiment Station bulletin or circular which should be used in referring to these publications.

For copies of bulletins or circulars or for other information address

THE ENGINEERING EXPERIMENT STATION,
UNIVERSITY OF ILLINOIS,
URBANA, ILLINOIS.

UNIVERSITY OF ILLINOIS
ENGINEERING EXPERIMENT STATION

CIRCULAR No. 9

FEBRUARY 14, 1921

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STATION OF THE UNIVERSITY OF ILLINOIS

BY
CHARLES RUSS RICHARDS
DIRECTOR OF THE ENGINEERING EXPERIMENT STATION AND
DEAN OF THE COLLEGE OF ENGINEERING

ENGINEERING EXPERIMENT STATION

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THE FUNCTIONS OF THE ENGINEERING EXPERIMENT STATION OF THE UNIVERSITY OF ILLINOIS

I. INDUSTRIAL RESEARCH

Until recently, comparatively few of the engineering industries appreciated the value of research. Now most of them are alive to its importance and many of them have undertaken its promotion by one means or another. A few of the large industrial organizations have developed splendidly equipped research laboratories devoted to the solution of problems of fundamental importance to their own interests and not infrequently to the advancement of pure science.* Other organizations have developed laboratories ostensibly devoted to research but really devoted to routine testing incident to the manufacture of their product and to the development of new machines, products, or processes. During recent years, a considerable number of trade associations have been organized to study and promote the interests of the firms having membership in these associations, and in many of them important research work has been undertaken in laboratories which they have developed, or in coöperation with private or public laboratories.†

It is difficult to determine when a single corporation or an association of concerns having a community of interests is justified in organizing an independent research laboratory. The great expense incurred in the operation of such laboratories, the difficulty of securing properly trained and competent men to do research work, and the failure to recognize the nature of the problems to be solved are likely to bring many of these laboratories, as well as research in general, into disrepute. In many instances, more satisfactory results may be obtained at a smaller cost through coöperation with private or public laboratories.

* Bulletin No. 2, entitled, "Research Laboratories in Industrial Establishments of the United States," prepared by the National Research Council, 1701 Massachusetts Avenue, Washington, D. C., presents a complete list of such laboratories.

† An interesting *résumé* of the activities of these various trade organizations was presented by Mr. Wharton Clay, a graduate of the College of Engineering of the University of Illinois, in an article entitled, "Engineering in Trade Association Work," which appeared in the March 20, 1920, issue of the Journal of the Western Society of Engineers.

II. THE ENGINEERING EXPERIMENT STATION

The Engineering Experiment Station of the University of Illinois, the first of its kind in existence, was created by an act of the Board of Trustees on December 8, 1903, in recognition of the need for more accurate knowledge of the materials and processes of engineering, and the conservation of those resources upon which the engineering industries depend. The Station has been helpful in stimulating engineering education and it has rendered a distinct service to professional engineers and to the industries of the State and Nation.

The management of the Engineering Experiment Station is vested in an Executive Staff composed of the Director and his Assistant, the Heads of the several departments of the College of Engineering and the Professor of Industrial Chemistry. This Staff is responsible for the establishment of general policies governing the work of the Station, including the approval of material for publication. All members of the teaching staff of the College are encouraged to engage in scientific research, either directly or in coöperation with the Research Corps, composed of full-time research assistants, research graduate assistants, and special investigators. Those employed for special investigations are engaged for a limited time on a single problem.

It is the purpose of this circular to present and describe the functions of the Engineering Experiment Station as they have been developed at the University of Illinois. •

III. GENERAL RESEARCH

Each department of engineering represented in the Engineering Experiment Station is conducting research work in various fields, which has been initiated by members of the teaching and scientific staffs, and which is carried on by them with funds regularly available for the work of the Station. Most of the investigations thus far completed by the Station have been financed with University funds. In general, the investigations thus undertaken are such as have a peculiar appeal to these members of the staff because of their knowledge of the need for reliable information in particular subjects, resulting from their own professional experience or study, and their desire to secure it. Such work is particularly stimulating to teachers of engineering subjects, and it is generally valuable to professional engineers and to the industries.

Many of the results of investigations already completed by the Station have had a large influence in the development of engineering science and practice. They have been widely quoted by the technical press, and extensively used in numerous engineering treatises.

IV. PUBLICATIONS

To render the results of its scientific investigations available to the public, the Engineering Experiment Station publishes and distributes a series of bulletins. Occasionally it publishes circulars of timely interest, presenting information of importance compiled from various sources which may not be readily accessible to the clientele of the Station.

All these publications are regarded as contributions to the literature of engineering, and many of them present important additions to the science of engineering. All publications are distributed free to those persons who are on the regular mailing list of the Station, and to others upon request. After the number of copies of a particular bulletin, however, has been reduced to an established limit, a small charge is made for each of those remaining for distribution. A charge is also made for duplicate copies of a particular bulletin when these are requested by an individual, unless in special cases it is deemed advantageous to the Station to furnish such duplicates free. When ordered in large quantities, a special rate for bulletins may be made by the Director.

Upon request to the Director, the name of any person who desires to receive the publications of the Engineering Experiment Station, as they are issued, will be added to the regular mailing list. A circular containing a complete list of the publications will be sent to any one who may desire it.

Too great emphasis cannot be laid upon the importance of these publications. They afford a medium for the prompt presentation of valuable information and data which might not otherwise be readily available to those who can use them. The conduct of research work without the publication of the results represents an expenditure of funds from which no adequate returns are secured.

V. GENERAL SERVICE

As the work and activities of the Engineering Experiment Station have become known, the officers of the Station have received a constantly increasing number of requests for specific information and advice upon a great variety of subjects. Each inquiry is referred to that member of the staff who is competent to answer it, and the response is made without charge when the information desired can be supplied without special research. When the information requested would demand a special investigation, requiring the expenditure of money or of much time, or in cases which would involve the expression of an opinion based upon insufficient data, it is customary to recommend the employment of a consulting engineer, or the services of a commercial laboratory. In some cases inquiries of the kind under consideration may lead to requests for commercial tests or coöperative investigations. The regulations governing such tests and investigations are presented in sections VII and VIII.

VI. THE TRAINING OF MEN FOR RESEARCH WORK

One of the most important functions of the Engineering Experiment Station is the training of men in the methods of scientific research, and possibly the chief advantage in organizing the Station at the University, rather than as an independent research bureau, lies in the fact that the institution attracts many brilliant young men who desire to pursue graduate studies and become prepared to do scientific work. A commercial laboratory or public research bureau cannot offer equal opportunities for advanced study under direction. They must, therefore, look to the universities for their supply of research men. The stimulus to those professors who are directing the work of graduate students, working with them in the solution of scientific problems is doubtless responsible for the fact that very many of the most important discoveries in science have emanated from institutions of higher education.

The Station employs a considerable number of full-time research assistants, of various academic rank, each of whom is attached to some one of the departments engaged in research. Many of these men are experts in research; others are beginners who need to be developed. In addition to this full-time research staff, the University of Illinois now maintains fourteen Research Graduate Assistantships in the Engineering Experiment Station, together with two Research Graduate Assistantships in Gas Engineering which have been established under the patronage of the Illinois Gas Association. These Assistantships are open to graduates of approved American and foreign universities and technical schools who are prepared to undertake graduate study in engineering, physics, or applied chemistry. Each assistantship carries a stipend of six hundred dollars, and freedom from tuition, incidental, and laboratory fees. Appointment to these positions must be accepted for two consecutive collegiate years, at the expiration of which period, if all requirements have been met, the degree of Master of Science will be conferred. Not more than half of the time of these assistants, during ten months of each year, is required in connection with the work of the department to which they are assigned; the remainder is available for graduate study.

Information concerning the opportunities for graduate study in engineering will be found in the circular of the Graduate School of the University of Illinois, which may be obtained upon request to the Dean of the Graduate School. Further details regarding appointment to the Research Graduate Assistantships will be supplied upon request by the Director of the Engineering Experiment Station.

VII. COMMERCIAL TESTS AND INVESTIGATIONS

The Engineering Experiment Station is frequently requested to do commercial testing, varying in its nature from the simple calibration of instruments and tests of materials to the performance of elaborate investigations of materials, machines, or processes, the results of which are to be considered confidential, and available only to the individual or corporation for which the tests were made. Such tests are frequently desired in connection with the invention, development, or improvement of some machine or process, to determine the properties of a material to be employed in an engineering structure, or for the establishment of engineering data necessary for the successful design of apparatus or structures. In some cases, such tests are desired by promoters solely for advertising purposes because of the belief that tests made in such an institution will carry the inference that the device or process tested is endorsed by the institution.

The Engineering Experiment Station will not undertake commercial tests except under unusual circumstances. Such tests interrupt regular Station work, and where an immoderate number of them is undertaken, the antagonism of consulting engineers and of commercial laboratories may be aroused. Since the Engineering Experiment Station was organized without any thought of financial gain, it is difficult to justify commercial testing except in those cases where the work cannot readily be undertaken elsewhere, and where its prosecution may be of direct or indirect benefit to the community.

The conditions under which the University will undertake commercial or coöperative investigations or tests have been formulated by the Board of Trustees as follows:

“1. When the University undertakes a scientific investigation or piece of research, whether of its own initiative or at the request of outside parties, the results of the investigation are the property of the University, to be given to the public for the advance of knowledge. The University will not in any case make an agreement with an individual or corporation to give it permanently the exclusive benefits of the results of such investigation, or research, even though the investigation, or research be conducted with money contributed by said individual or corporation.

“2. The University stands ready at all times, within the limit of its means and its responsibilities, to coöperate with any individual or corporation in helping

it to solve its specific technical problems and to overcome difficulties or accomplish improvements in its processes in all cases in which the problem to be solved is peculiar to the individual corporation asking help from the University, and is not a problem the results of which are in the nature of information which, if disseminated among the people, could be utilized by the public at large as a means of advancing knowledge or improving conditions of life. However, when the University undertakes such coöperation, it will be in return for payment, according to terms agreed upon between the University and the other party concerned." *

All inquiries regarding commercial tests should be addressed to the Director of the Engineering Experiment Station; and all arrangements for conducting such tests must be made by him, subject to the approval of the President of the University, as provided in Section 21 of the University Statutes.

For each commercial test undertaken by the Engineering Experiment Station, a fee will be charged to cover all service rendered and assistants employed, all materials used, the purchase of any necessary special equipment, the wear and tear or repairs of equipment used, and the use of any other of the facilities of the University employed in the conduct of the test. Should a test involve large expenditures of money, the University will require an initial deposit and subsequent payments sufficient in amount to maintain a reasonable working balance in the treasury of the University, so that prompt payment of bills rendered on account of the test may be made. All fees thus charged shall be reported by the Head of the department concerned through the Director of the Engineering Experiment Station to the Business Office for collection.

A member of the teaching staff who is requested and authorized to undertake a commercial test, as an extra activity outside of his regular University duties, may make direct arrangements for the payment of a fee for his services with the individual or company for which the test is made, subject, however, to the approval of the Director of the Engineering Experiment Station.

* Minutes of the Board of Trustees, page 76, September 14, 1920.

VIII. COÖPERATIVE RESEARCH

Coöperation between the Engineering Experiment Station and individuals, firms, corporations, or associations in the conduct of engineering research affords the most inspiring opportunities for the investigation of large and important problems, the solution of which involves expenditures that are too large for the institution to provide; for the performance of a service of immediate importance and of great value to engineers and the public; and for the establishment of relations which will be of mutual advantage to the industries and the Station. The chief obstacle to the establishment of such coöperative relations is the still prevalent but mistaken notion that scientific knowledge secured at the expense of a particular industrial organization should be the sole property of that organization to be used exclusively for its own advantage. Obviously, the Engineering Experiment Station, which is supported chiefly by public funds, cannot be employed in the exploitation of inventions or processes, or in the conduct of scientific work, the benefits of which are to be withheld from the public. Furthermore, in these days of scientific achievement no organization can long hope to keep a "trade secret," if a competitor really desires to learn the truth concerning it. Undoubtedly a free interchange of knowledge of importance in a particular industry will benefit every concern represented, by standardizing and improving the product, and by establishing the confidence of the public therein.

Coöperative research will be undertaken only in those instances where its chief purpose is to establish fundamental principles and physical laws which may have a wide, practical application. The establishment of such laws is of direct or indirect benefit to every person, since it permits the substitution of exact knowledge for empirical methods in the design, construction, or utilization of the materials and processes of engineering. While engineers or special industries may be primarily benefited through the extension of scientific knowledge in a particular field, the public is undoubtedly benefited because commodities which it needs may be produced more economically and of better quality.

In establishing relations for the conduct of a coöperative investigation, the Engineering Experiment Station will contribute the use

of all of its facilities, including its laboratories and equipment, together with heat, light, power, water, etc. It will assume the general direction and administration of the investigation, and it will publish all of the results secured and conclusions formulated as a result of the investigation. The coöperating agency is required to provide such funds as are necessary to pay the salaries of special investigators employed exclusively in the conduct of the particular investigation, for the purchase of materials and special apparatus needed for the work and not already available in the Station laboratories, and for other necessary expenses of the investigation. In all contracts for coöperative research work which have been entered into by the University of Illinois through its Engineering Experiment Station, ownership of data secured, together with the right to publish these data and conclusions resulting therefrom, is reserved by the Station. The public is thus protected against the use for private gain of an institution which it supports. The University of Illinois further declines to permit the use of data so secured in advance of the complete publication of the results, unless it be with the understanding that any individual or corporation interested may have equal rights with the coöperating agency.

Under normal circumstances, it is to the advantage of both parties to an agreement for the conduct of coöperative research to provide for the appointment of a competent Advisory Committee, which will assist the officers of the Station in outlining its program for the investigation, and which will represent the organization coöperating in the investigation, so that the general nature of the problems to be investigated can be determined and so that greater assurance of the practical value of the results may be attained. Obviously, since the Station must be responsible for the results secured in any investigation, it must be free to determine the methods pursued in carrying on the work. An Advisory Committee is desirable and helpful unless it assumes the right to dictate concerning methods and policies.

The following form of contract will illustrate in a general way the conditions under which the University of Illinois, through its Engineering Experiment Station, is willing to undertake coöperative research :

ARTICLES OF AGREEMENT between the Board of Trustees of the University of Illinois, Party of the First Part, and....., Party of the Second Part, for a coöperative investigation of, by the University, through its Engineering Experiment Station, a division of the said University, under the following terms and conditions:

(1) This agreement is executed for a period of years beginning, with the understanding that it may be extended for additional periods under the same terms or such other terms as may be mutually agreed upon.

(2) The University of Illinois will delegate..... (or some other competent person should his connection with the University cease) to supervise and direct all experimental work and the computation and reduction of all results obtained, together with the placing of these data into form for presentation; and he will be authorized to give such portion of his time to this investigation as may be necessary for the effective promotion of the work.

(3) The University will furnish the necessary room for this investigation, together with heat, light, power, and water. In addition, it will permit the use of such laboratory apparatus as it may possess, which is not in use for other purposes. It is agreed, however, that all special apparatus necessary for this investigation and not available in the laboratories of the Engineering Experiment Station of the University shall be purchased from, and charged against, the funds provided by..... for this purpose.

(4) An Advisory Committee acceptable to and the Director of the Engineering Experiment Station, shall be appointed to advise with the officers of the Engineering Experiment Station of the University concerning the test program and the conduct of the investigation, and to coöperate in the preparation of all reports. The conduct of the tests shall be under the full control of the University through the Engineering Experiment Station, which is necessarily responsible for the results secured.

(5) (a) All the records of the investigation are to be the property of the University of Illinois and they are to be kept on file by the Engineering Experiment Station.

(b) The University through the Engineering Experiment Station shall have the exclusive right to publish the results of the investigation as a bulletin or bulletins of the Station. The bulletin shall contain a detailed description of the investigation and a full report of the results and conclusions. No publicity shall be given to any of the results of the investigation prior to the publications of these results by the Engineering Experiment Station except upon the recommendation of the Advisory Committee and by agreement with the Executive Staff of the Station. In every publication, proper credit shall be given the Advisory Committee, and every one who has made a significant contribution to the results obtained.

(6) The Advisory Committee and authorized representatives of....., as well as others interested, shall at all times have access to the data secured and computed results of the tests, subject, however, to the restrictions named in Article 5. The Engineering Experiment Station will submit such reports of progress to as may seem desirable to the Advisory Committee.

(7) All research assistants, mechanics, clerks and other help necessary for the effective prosecution of this investigation will be employed by the University through the Engineering Experiment Station and paid from the fund provided by The members of the special staff for this investigation are to be regarded as members of the Research Corps of the Engineering Experiment Station of the University during their connection therewith.

(8) On or before, the..... shall pay to the Board of Trustees of the University of Illinois the sum of \$..... and thereafter the sum of \$..... at stated intervals as follows:.....

It is understood and agreed that the payment of the above sums as stipulated is conditioned upon the conduct of the investigation by the University of Illinois with due diligence so as to secure the greatest possible progress consistent with the nature of the work. If it should appear that, because the rate of expenditure is not so rapid as the rate of payment as indicated above, funds are unduly accumulating in the treasury of the University of Illinois, payments may be correspondingly deferred.

The money contributed for this investigation shall be held as a special fund and shall be so carried on the books of the Comptroller of the University. Payments from this fund shall be made only on vouchers approved by the Director of the Engineering Experiment Station for this work. At the close of each year covered by this agreement the Comptroller will render an accounting to.....*

* Obviously each contract entered into by the University for a coöperative investigation will involve special conditions, some of which may not be included in the above general form.

On September 14, 1920, the Board of Trustees approved the following regulations concerning the drafting and execution of contracts (Minutes, pages 77-78):

"1. Contracts shall be drafted in tentative form by the University officer (or officers) who is best acquainted with the subject matter thereof, and in whose department lies the responsibility for the execution thereof, and approved by the President of the University.

"2. All contracts prior to execution thereof shall be approved as to legal form by the University Counsel; such approval to be endorsed in writing on the contract.

"3. All contracts shall be executed at least in duplicate; an original thereof shall be filed with, and remain in the custody of, the Secretary of the Board of Trustees.

"4. The Secretary of the Board of Trustees shall immediately file a true copy of all contracts, one in the office of the Comptroller of the University, and one with the proper officer in charge of the department immediately concerned with the execution of the subject matter of the contract.

"5. All University contracts shall be executed as follows, to wit:

"(a) All major contracts or those involving some general University policy shall be signed by the President and Secretary of the Board of Trustees, unless directed to be otherwise executed by the Board of Trustees or the Executive Committee thereof.

"(b) Minor contracts and those involving the purchase of ordinary supplies, advertising and publicity matters, and other routine matters in the ordinary operation of University affairs, shall be signed by the Secretary of the Board of Trustees and by the Comptroller of the University, to whom authority is hereby delegated by the Board for such purpose.

"(c) All contracts must have the seal of the University attached."

IX. PATENTS

In the conduct of research work a new process may be discovered or inventions perfected having a commercial value. After several important discoveries of this kind had been made in the Engineering Experiment Station of the University of Illinois, it became evident that some policy should be established which would safeguard the interests of the institution and of the public which created it and which it serves. After mature consideration of the questions involved in this very important matter, the following regulations were formulated by the officers of the Engineering Experiment Station and approved by the Board of Trustees:*

“In connection with the work of the College of Engineering and the Engineering Experiment Station, discoveries or inventions of commercial value will occasionally be made, and it is desirable in such cases that the interests of the University and of the public be safeguarded. The University is a state institution supported by public funds, and it is its duty to preserve for the use of the public all benefits accruing from investigations made by the University or under its auspices. A procedure should be followed which will conserve the rights of the University and of the public in the utilization of the discoveries and inventions and which will preclude the appropriation of the results of investigations by private interests through patents or other restrictions in such a way as to deprive the public of advantages and benefits properly belonging to it. It would seem that a proper way to safeguard all interests lies in taking out patents and in administering such patents in a manner which will best serve the interests of the public, the University, and the workers in the University.

“To insure the protection desired, the Executive Staff of the Engineering Experiment station recommends

“(1) That the principle be recognized that the results of experimental work carried on by or under the direction of the scientific or teaching staff of the College of Engineering and the Engineering Experiment Station, and having the expense thereof paid from the University funds or from funds under the control of the University, belong to the University and the public and should be used and controlled in ways to produce the greatest benefit to the University and the public.

“(2) That in case of valuable discoveries and inventions resulting from experimental work or of discoveries and inventions which may be expected to have a basic relation to other discoveries or inventions of commercial importance, the practice be established of taking out patents to be controlled by the Univer-

* Minutes of the Board of Trustees, pages 661-664, February 16, 1918.

sity, and that any member of the scientific or teaching staff of the College of Engineering who has made a valuable discovery or invention as the direct result of his regular duties on University time and at University expense may be required to patent his discovery or invention, the expenses connected therewith to be borne by the University.

“(3) That application for a patent to cover such discoveries or inventions shall be made in such cases as are recommended by the Staff of the Engineering Experiment Station and approved by the President of the University, and that upon its issue the patentee shall assign the patent to the Board of Trustees of the University of Illinois for a nominal consideration.

“(4) That the Board of Trustees administer the rights under the patents in ways to suit the conditions,—dedicating the patent to the public or licensing its use. In case of license, the license shall be made with provisions for the use of the patent that will safeguard the public during the life of the patent from unreasonable restrictions or exorbitant royalties for the use of later patents which may depend upon a University patent for their usefulness.

“(5) That in the event any sum above a nominal royalty is received by the University for the use of the patent a proper share of it shall be paid to the patentee.

“(6) That in the case of coöperative investigations special agreements for preferential licensing may be made with the coöperative interests with a view to compensating for the assistance rendered in the investigation.

“(7) That the action herein proposed shall not be construed to include questions of ownership in copyrights on books or of inventions or discoveries made by members of the teaching or scientific staffs outside their regular duties and at their own expense.”

While such regulations concerning patents may not be so important in privately endowed institutions, they are, for reasons stated elsewhere, of very great importance in publicly supported institutions, to prevent the possibility of destructive criticism which would follow any use of the institution's facilities for the development of inventions or processes for private gain. It is believed that the sixth clause, which provides for preferential licensing for the use of patents taken out as a result of coöperative investigations, is as far as the University may safely go in dealing with problems connected with such patents.

X. COÖPERATIVE INVESTIGATIONS IN PROGRESS

The following coöperative investigations are now in progress, or have been recently completed in the Engineering Experiment Station:

(a) **Investigations of Coal Mining in Illinois**, in coöperation with the U. S. Bureau of Mines, and the Illinois State Geological Survey. These investigations include studies of the mining, preparation, and utilization of Illinois coal. The results of completed investigations are presented in a series of thirty bulletins, twelve of which are published by the Engineering Experiment Station, sixteen by the Illinois State Geological Survey and six by the U. S. Bureau of Mines.

(b) **Investigations of the Manufacture of Gas from Illinois Coal** have been carried on by the agencies named in the preceding paragraph in coöperation with the Illinois Gas Association. These investigations have included studies of the utilization of Illinois coal as generator fuel, of the purification of gas, and the prevention of the formation of tar emulsions. In addition to this coöperative arrangement, the Illinois Gas Association maintains two Research Graduate Assistantships in Gas Engineering in the Engineering Experiment Station for the study of problems of interest to the industry.

(c) **Investigation of the Coking of Coal** in coöperation with Mr. A. T. Hert of Louisville, Kentucky. In his work in the Engineering Experiment Station, Professor S. W. Parr has made many studies of coal, with special reference to its coking properties, which were of such importance as to lead to an extension of these investigations on a larger scale through the coöperative agreement with Mr. Hert.

(d) **Investigation of the Stresses in Railway Track**, in coöperation with committees of the American Society of Civil Engineers and the American Railway Engineering Association. This investigation was undertaken to determine the stresses in the rail and tie, and the distribution of pressure through the ballast and road bed. Two reports of progress have already been made to the coöperating societies and published by them.

(e) **Investigation of the Stresses in Chilled Cast Iron Car Wheels** in coöperation with the Association of Manufacturers of Chilled Iron Car Wheels. The investigation includes elaborate tests to determine the stresses resulting from the forcing of the wheel on the axle, those due to the direct load of the car, those due to temperature variations resulting from prolonged application of the brakes, etc.

(f) **Investigation of the Effect of the Size of Coal on Locomotive Performance**, in coöperation with the International Railway Fuel Association. The results of this investigation are presented in Bulletin No. 101.

(g) **Investigation of Warm-Air Furnaces and Furnace Heating**, in coöperation with the National Warm-Air Heating and Ventilating Association, to determine the efficiency and methods of rating warm-air furnaces and to solve the problems connected with their successful installation and operation.

(h) **Investigation of the Fatigue Phenomena of Metals**, in coöperation with the Engineering Foundation and the National Research Council, to establish, if possible, the conditions affecting the failure of metals subjected to repeated stress. The original program for this investigation has been extended to include the study of certain special problems, in coöperation with the General Electric Company and the other agencies named.

(i) **Investigation of the Viscosity and Electrical Conductivity of Glass**, in coöperation with the National Research Council, through the Corning Glass Works Fellowship.

(j) **Investigation of the Friction Losses and Power Requirements** in the Proposed Ventilating System for the New York and New Jersey Vehicular Tunnel to be constructed under the Hudson River, in coöperation with the U. S. Bureau of Mines acting for the New York State Bridge and Tunnel Commission and the New Jersey Interstate Bridge and Tunnel Commission.

THE UNIVERSITY OF ILLINOIS

THE STATE UNIVERSITY

Urbana

DAVID KINLEY, Ph.D., LL.D., President

THE UNIVERSITY INCLUDES THE FOLLOWING DEPARTMENTS:

The Graduate School

The College of Liberal Arts and Sciences (Ancient and Modern Languages and Literatures; History, Economics, Political Science, Sociology; Philosophy, Psychology, Education; Mathematics; Astronomy; Geology; Physics; Chemistry; Botany, Zoology, Entomology; Physiology; Art and Design)

The College of Commerce and Business Administration (General Business, Banking, Insurance, Accountancy, Railway Administration, Foreign Commerce; Courses for Commercial Teachers and Commercial and Civic Secretaries)

The College of Engineering (Architecture; Architectural, Ceramic, Civil, Electrical, Mechanical, Mining, Municipal and Sanitary, and Railway Engineering; General Engineering Physics)

The College of Agriculture (Agronomy; Animal Husbandry; Dairy Husbandry; Horticulture and Landscape Gardening; Agricultural Extension; Teachers' Course; Home Economics)

The College of Law (Three-year and four-year curriculums based on two years and one year of college work respectively)

The College of Education (including the Bureau of Educational Research)

The Curriculum in Journalism

The Curriculums in Chemistry and Chemical Engineering

The School of Railway Engineering and Administration

The School of Music (four-year curriculum)

The Library School (two-year curriculum for college graduates)

The College of Medicine (in Chicago)

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Experiment Stations and Scientific Bureaus: U. S. Agricultural Experiment Station; Engineering Experiment Station; State Laboratory of Natural History; State Entomologist's Office; Biological Experiment Station on Illinois River; State Water Survey; State Geological Survey; U. S. Bureau of Mines Experiment Station.

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